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ABSTRACT

A framework for describing relationships among the different linguistic systems in a bilingual or second language learner is proposed. The framework attempts to represent the ways in which knowledge of one language is used in integrating into memory new knowledge about another language. The model is partially implemented in a computer program that generates Japanese and English sentences. In the first section, a model characterizing the units of linguistic knowledge and how these units are used in processing is outlined. The second section discusses, within the framework of this model, the possible relationships between units of linguistic knowledge for different languages. The main features of the lexical memory model are that: (1) the units of linguistic knowledge are generalized utterances, generalizations about how sequences of linguistic acts achieve pragmatic goals or convey semantic content; (2) these generalized utterances are arranged in a type hierarchy integrating specific knowledge (lexicon) and general knowledge (grammar); and (3) processing is a matter of classifying input as instances of generalizations in memory and inheriting information from the generalizations. (MSE)

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by

Michael Gasser

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MEMORY ORGANIZATION IN THE BILINGUAL/SECOND LANGUAGE LEARNER: A COMPUTATIONAL APPROACH*

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A key question for second language acquisition theory is that of how knowledge of one language is used in integrating knowledge of another language into memory. A closely related question, also of interest for research on bilingualism and translation, is that of how knowledge of one language is used in comprehending and producing utterances in another language. To begin to address these issues, the project reported on in this paper has the goal of developing a computational framework for describing relationships among the different linguistic systems in a bilingual or second language learner. The model is partially implemented in a computer program which generates Japanese and English sentences.

The first part of this paper gives an outline of a model characterizing the units of linguistic knowledge and how they are used in processing. The second part discusses, within the framework of this model, the possible relationships between units of linguistic knowledge for different languages.

Linguistic Units and their Use in Processing

Any consideration of the knowledge possessed by a speaker of two or more languages presupposes a model of the nature of linguistic knowledge itself. The approach adopted here is referred to as the **Lexical Memory** model (Gasser & Dyer, 1986). It is a computational model in that it is explicit about both the structure of linguistic memory and how it is utilized in comprehension and production; competence and performance are treated as interdependent aspects of language (Winograd, 1983). Though the model differs considerably from most work in computational linguistics, it is consistent with a range of current work in linguistics, psycholinguistics, and artificial intelligence, in particular, with approaches emphasizing the primacy of form-function mappings (Fauconnier, 1985; Hudson, 1984; Kirsner, 1979; Langacker, 1986; MacWhinney, in press; Wilensky & Arens, 1980); with work stressing idiomaticity and phrasal lexical units (Fillmore, 1979; Pawley & Syder, 1983; Peters, 1983; Wilensky & Arens, 1980; Zernik & Dyer, 1986); with approaches which see commonalities between linguistic and other knowledge (Anderson, 1983; Hudson, 1984; Langacker, 1986); and with frame-based, hierarchical models of memory organization (Fahlman, 1979; Jacobs, 1985; Schank, 1982).

For the purposes of this paper, the main features of the Lexical Memory model are the following:

1. The units of linguistic knowledge are **generalized utterances** (GUs), generalizations about how sequences of linguistic acts achieve pragmatic goals or convey semantic content.
2. GUs are arranged in a type hierarchy integrating specific knowledge (lexicon) and general knowledge (grammar).
3. Processing is a matter of **classifying** inputs as instances of generalizations in memory and **inheriting** information from the generalizations.

Unlike most linguistic models, this one starts with what linguistic knowledge shares with other knowledge. All of memory has the form of a **semantic network**, a familiar representational formalism in cognitive science. The particular semantic network scheme adopted here is based on Fahlman's NETL (1979). A semantic network consists essentially of a hierarchical network of generalizations. A **generalization** is a description of a prototypical member of a set of **instances**. A generalization (or, more precisely, the node in memory representing the generalization) is joined to its instances by **is-a links**. An is-a link also joins a generalization to one or more higher-level generalizations which subsume it. In the figures in this paper generaliztion and instance nodes are represented by rectangles and is-a links by arrows pointing toward the more general node. Names of concepts, including generalizations and instances, are written in small capitals. Note that the

names are used only for convenience; they have no significance for the processes that operate on the network.

A generalization gets its meaning from the connections it has with a set of other concepts, called **roles**, which characterize each instance of the generalization. In the figures role nodes are shown embedded within their generalization node. Consider a non-linguistic example, generalization about the notion of taking a class. The generalization TAKE-CLASS has, among other roles, a CLASS-TAKER, a CLASS-TAKEN, and a set of roles for the sub-acts, or EXPANSIONs, which constitute taking a class, including GO-TO-CLASS and DO-ASSIGNMENT. Each of these roles, in turn is connected to other generalizations in memory via is-a links. The CLASS-TAKER, for example, is an instance of the generalization STUDENT (Figure 1).

Now consider a linguistic example, generalization about the use of the expression *take a class* and related expressions such as *take Chemistry 101* and *take a seminar*. This is a generalization over a set of **utterances**, or meaningful uses of language. Every utterance has a number of roles, including in particular a set of EXPANSIONs specifying the constituents of the morpho-syntactic pattern that realizes the utterance; a CONTENT, the concept the utterance is designed to activate or create in the listener's memory;[1] a SPEAKER; a LISTENER; and a communicative OBJECTIVE of the speaker. In the Lexical Memory model, the basic units of linguistic knowledge are **generalized utterances** (GUs), each of which provides some information about one or more of these roles. GUs correspond to both lexical entries and phrase structure rules. Names of GUs begin with the prefix "U."; the one we are concerned with is U.TAKE-CLASS. What can we say, then, about all instances of the expression *take a class*? For one thing, they all have a CONTENT which is an instance of the concept TAKE-CLASS. For another, they all have a HEAD (verb), one of the utterance EXPANSIONs, which is a form of *take*. To represent this last fact, we first note that, since roles are concepts, they can have their own roles. The HEAD of a clause, for example, has a STEM. In the case of U.TAKE-CLASS, the STEM has a particular phonological realization, indicated in the figure by the phonemic notation (Figure 1) This stipulation is overridden for irregular forms of *take*.

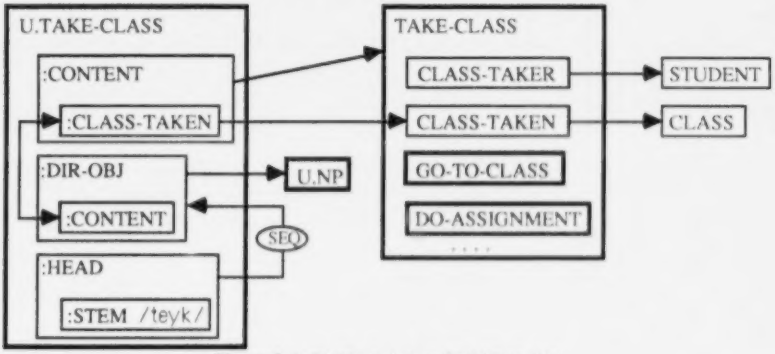

Figure 1: U.TAKE-CLASS and TAKE-CLASS

We can also say something about the subject and direct object of U.TAKE-CLASS, namely that the subject refers to the relevant CLASS-TAKER and the direct object to the relevant CLASS-TAKEN. In order to see how this sort of case assignment is handled, we first need to look more closely at what is meant by an is-a link, in this case the one joining the CONTENT of the clause to the generalization TAKE-CLASS. The significance of the link is that all of the roles in the more general concept are implicitly **inherited** by the more specific concept. Therefore the CONTENT of the U.TAKE-CLASS generalization has its own CLASS-TAKER and CLASS-TAKEN roles. The fact that these roles are inherited is denoted by the colon in their names. Note that they are joined to the roles which they correspond to by is-a links.[2] Next we create roles for the SUBJECT and

DIRECT-OBJECT, which, like the HEAD, are utterance EXPANSIONs, but unlike the HEAD, are considered utterances in themselves since they have their own CONTENT. All that is left is to equate the CONTENT of the SUBJECT with the CLASS-TAKER of the CONTENT of the whole clause and the CONTENT of the DIRECT-OBJECT with the CLASS-TAKEN of the clause CONTENT. In Figure 1 this relationship is shown for the DIRECT-OBJECT. An **equivalence link** is denoted by a two-headed arrow.

One further piece of knowledge characterizing U.TAKE-CLASS is the default ordering of the constituents. Sequencing is represented by explicit **sequence links**, one of which is shown in Figure 1. This link indicates that the HEAD (verb) precedes the DIRECT-OBJECT.

There is one problem with U.TAKE-CLASS as shown in Figure 1. It includes information that perhaps belongs elsewhere. For example, the particular form of the HEAD STEM is certainly a property of a wider range of utterances. This information might then be stored in a higher-level generalization, U.TAKE, encompassing all uses of *take* (Figure 2). Now U.TAKE-CLASS and other specializations of U.TAKE can share this information along with the irregular forms of the verb (though I have not shown how these irregular forms are represented). Because U.TAKE-CLASS inherits the role information in U.TAKE, there is no need to specify the HEAD in U.TAKE-CLASS, although redundant information such as this is not ruled out by the model.

Still higher-level generalizations could be made about the SUBJECT and DIRECT-OBJECT. Assuming for simplicity that the system has no knowledge of passive, this belongs in U.TRANSITIVE-CLAUSE, which stores information about the position of the DIRECT-OBJECT and about case assignment. The latter presupposes a semantic generalization for a category of event, TRANSITIVE-EVENT, and two of its roles, ACTOR and PATIENT. The knowledge that the DIRECT-OBJECT refers to the PATIENT role can be inherited by U.TAKE-CLASS once a correspondence is set up between the TAKEN-CLASS and PATIENT roles (Figure 2).

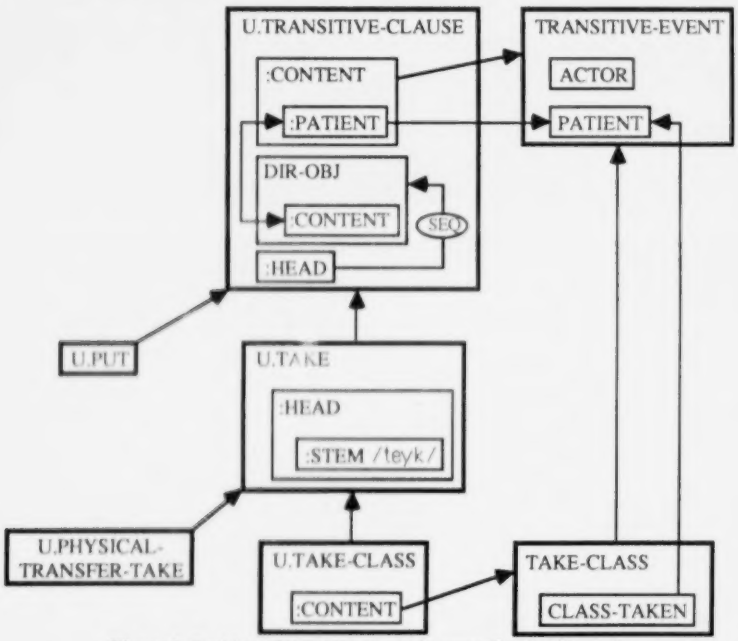

Figure 2: Position of U.TAKE-CLASS in generalization hierarchy

The example shows how lexical and grammatical knowledge is integrated in a single hierarchical network. A similar hierarchy of GUs exists for NPs.

The network of generalizations has no significance at all without a set of procedures to operate on it. There are two basic procedures, **classification** and **inheritance**. In this paper it is only possible to give an intuitive sense of what they accomplish. The network of generalizations functions as an inventory of alternatives to be used in processing new input. The purpose of processing is to fill in missing information in the input. A simple example is the task of recognizing a bird. The system starts with a partial characterization of the bird, say, its size, coloring, song, and habitat, and a goal to know something more, say, the species name of the bird. On the basis of the known information the system classifies the bird as an instance of some generalization, in this case, one for a particular species. Once this has been done, the name of the species can be explicitly inherited by the instance.

In the case of language, the input is an utterance instance. For comprehension this represents the utterance being parsed and for production the utterance being generated. Again there is initially a partial characterization and a goal to fill in what is missing. In the case of comprehension, what is provided is some or all of the EXPANSIONs, and the goal is to inherit the CONTENT or the speaker's OBJECTIVE in producing the utterance. In the case of production, which is of more immediate concern in this paper, it is the speaker's OBJECTIVE and/or the CONTENT which are given at the outset, and the goal is to fill in the EXPANSIONs which realize the utterance. Processing consists of classifying the input utterance as an instance of one or more GUs in memory on the basis of the given role information and inheriting the missing role information from these GUs. One difference from the bird classification example is that an utterance is normally viewed as a combination of several generalizations. For example, the individual utterance realized as the sentence *Is Mary taking Chem 101?* is an instance of the GUs U.YES/NO-INTERROGATIVE-CLAUSE, U.TAKE-CLASS, and U.PRESENT-PROGRESSIVE-CLAUSE.

Consider in informal terms what happens in the production of this particular sentence. The input utterance begins with an objective on the part of the speaker to know the truth value of the proposition 'Mary is taking Chem 101'. On the basis of the type of objective, the utterance is classified as an instance of U.YES/NO-INTERROGATIVE-CLAUSE. On the basis of the fact that the time-interval for the questioned proposition includes the time of utterance, the utterance is assigned to U.PRESENT-PROGRESSIVE-CLAUSE. On the basis of the fact that the proposition (the CONTENT) is an instance of TAKE-CLASS, the utterance matches U.TAKE-CLASS. From each of these GUs the utterance inherits certain of its morpho-syntactic properties. Figure 3 shows how the utterance (U1) fits into the network at this point and what it has inherited. Only a portion of what is given at the start of production appears in the figure; this is shown in fuzzy outline. A number of morpho-syntactic features have been inherited: a main verb (HEAD), an AUXiliary, a SUBJECT and a DIRECT-OBJECT as well as the sequencing of these constituents. In addition, the CONTENT roles of the SUBJECT and DIRECT-OBJECT have been assigned to semantic roles of the CONTENT of the clause. The utterance is of course not yet complete: the SUBJECT and DIRECT-OBJECT still need to be classsified on the basis of their CONTENT.

Linguistic Units for Two Languages and their Interrelationships

How does the picture change with the addition of knowledge of a second language? In order for the system to distinguish knowledge about the two languages, we first need high-level generalizations for each language (Figure 4). These differ, at least in part, in terms of what kind of listener they are appropriate for. This restriction on the listener is just one more condition that needs to be matched when appropriate GUs are being sought during processing. During production there is the possibility that a GU will be found which matches the input adequately except for this restriction. In such cases, the speaker may ignore it and continue searching for a GU for the appropriate language or may choose to use the other GU, either by translating it word-for-word into the target language or integrating it directly into the target language utterance. We shall see examples of these alternatives later.

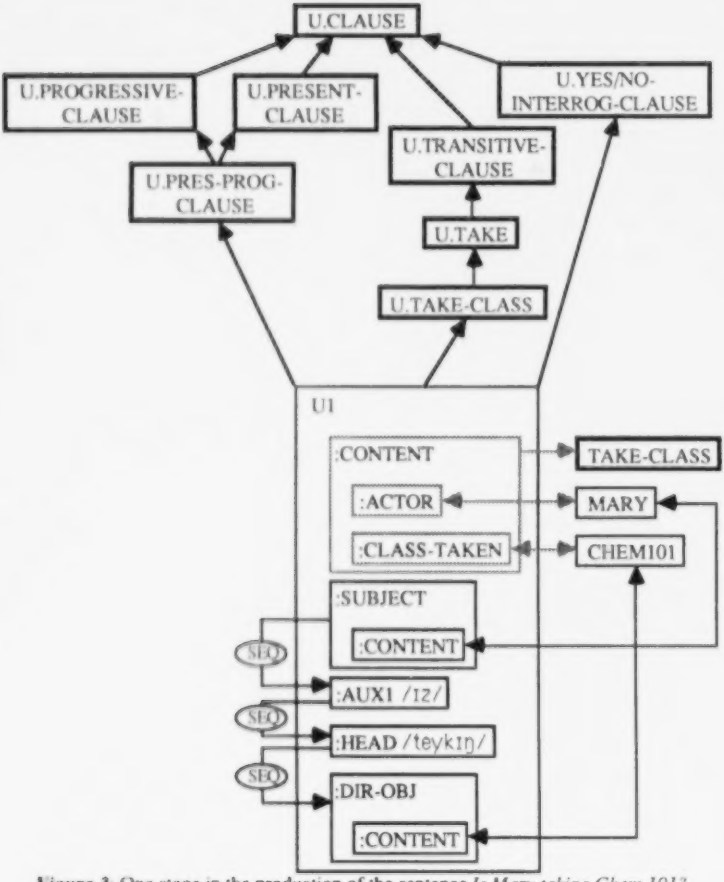

Figure 3: One stage in the production of the sentence *Is Mary taking Chem 101?*

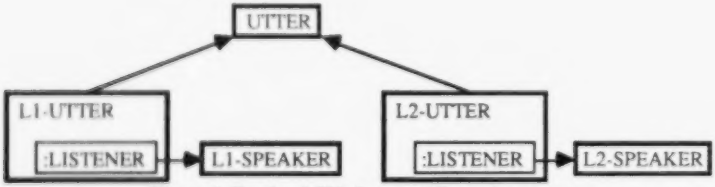

Figure 4: Top-level GUs for two different languages

Within the Lexical Memory framework, what are the possible relationships between GUs of different languages? One obvious possibility is that there is no relationship at all. This is certainly the case for the hard-to-translate expressions that everyone with experience learning a second language is familiar with. One Japanese informant gave as an example of such an expression the English phrase *tell me about it* in the sense 'I've had a similar unpleasant experience'. For this speaker, at least, there is no direct connection between the GU for this English expression and any Japanese GU.

However, this clearly won't work for cases of transfer. The following exchange contains an utterance which can only be accounted for in terms of transfer at some level. Speaker X is a native speaker of Japanese and an advanced speaker of English as a second language.

1) X: *The faucet's broken.*
   Y: *Which one?*
   X: ***Water***. (= 'cold water')

The problem is related to the fact that Japanese has a word consisting of a single morpheme meaning 'hot water' and another word meaning something like 'default water'. One way to represent the knowledge that the Japanese speaker has is shown in Figure 5. The concept WATER has two subtypes, HOT-WATER, defined in terms of its TEMPERATURE, and NOT-HOT-WATER, defined in opposition to HOT-WATER. A **distinctness link**, indicated in the figure by a line with filled circles on its ends, represents the relationship between HOT-WATER and NOT-HOT-WATER. COLD-TAP-WATER is then viewed as a specialization of NOT-HOT-WATER. The purely linguistic knowledge consists of two GUs, U.YU, with CONTENT an instance of HOT-WATER and HEAD /yu/, and U.MIZU, with CONTENT an instance of NOT-HOT-WATER and HEAD /mizu/. In producing a Japanese utterance corresponding to the English one above, the speaker would access U.MIZU via COLD-TAP-WATER and NOT-HOT-WATER.

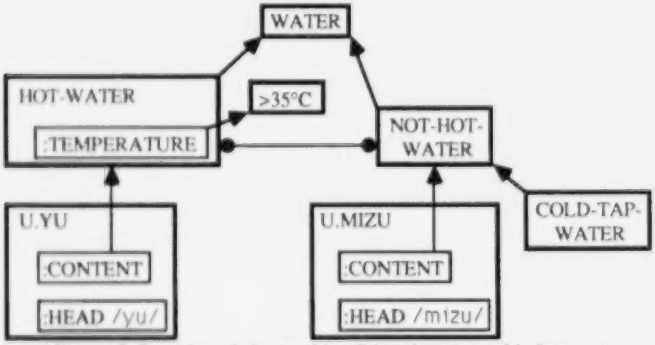

Figure 5: Some knowledge used in talking about 'water' in Japanese

How might the GU for English *water* be related to U.MIZU in a way that accounts for 1)? I will consider the following four logically possible types of relationships:

1. The CONTENT roles of the two GUs point to the same concept. For the water example, *mizu* and *water* both mean 'not-hot water' (Figure 6).
2. A language-independent GU has Japanese and English GUs as specializations. For the water example, there is a language-independent GU U.NOT-HOT-WATER* representing utterances about NOT-HOT-WATER in either language; the Japanese and English GUs, U.MIZU and U.WATER, inherit their CONTENT from U.NOT-HOT-WATER* and specify different HEADs (Figure 7).
3. Each utterance of one language has an associated TRANSLATION, a role representing an utterance of the other language with equivalent CONTENT (and/or speaker OBJECTIVE). Any

GU can specify that its TRANSLATION is an instance of a particular GU of the other language. For the water example, each instance of U.MIZU has a corresponding TRANSLATION which is an instance of U.WATER. This does not require that the two GUs have the same CONTENT, as long as their CONTENTs are consistent. For example, the CONTENT of U.WATER could be WATER, which is a generalization of NOT-HOT-WATER (Figure 8).

4. A word in one language is directly associated with a word in the other language. For the water example, what this would mean is that for each utterance which is an instance of U.MIZU it is possible to simply replace the Japanese HEAD *mizu* with the English noun *water* (Figure 9).

Figure 6: GUs of different languages with common CONTENT

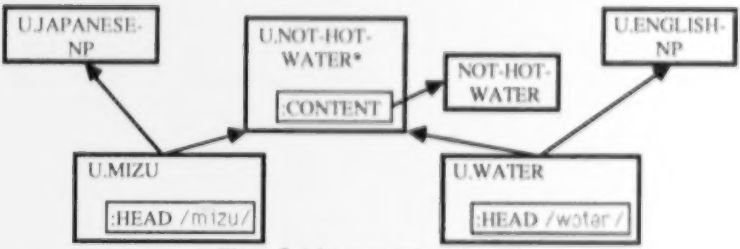

Figure 7: A language-independent GU

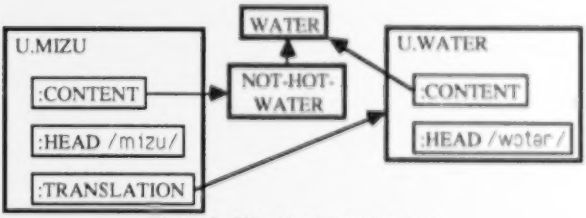

Figure 8: GU with a TRANSLATION

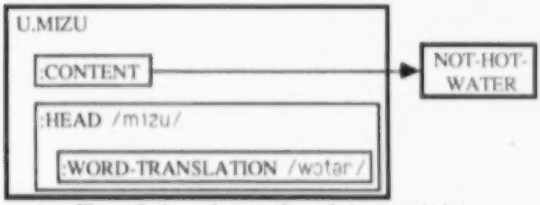

Figure 9: A word-to-word translation association

In the remainder of the paper, I discuss briefly what the significance of each arrangement is for acquisition and for production. The possibilities differ considerably with respect to the degree to which the L1 GU is relied on during acquisition of the L2 GU. Consider first the common-CONTENT arrangement (Figure 6). Here the CONTENT of the new L2 GU is assigned to an already available extra-linguistic concept, in the example, NOT-HOT-WATER. In this case the L1 GU is not directly accessed during acquisition, though it may have figured in the learning of the concept that the L2 GU is associated with.

In the case of the language-independent GU (Figure 7), the effect of the L1 GU is more direct. Here we can imagine a learning procedure which searches linguistic memory for an analogous L1 GU when an L2 GU is acquired. The analogy might be a semantic one, as in the example, but it might also be a morphological one, as in the case of cognates. For example, an English speaker learning the French word *important* would create a GU for both English and French specifying not only the CONTENT, but also the spelling, and, in some language-independent fashion, the pronunciation of the HEAD adjective.

For the TRANSLATION-role alternative, there are two separate possibilities. With an arrangement like that shown in Figure 8, we can imagine the L2 GU learned independently and only later associated with the L1 GU, perhaps as a consequence of a particular production strategy. Another possibility is for the L2 GU to be embedded in the L1 GU in the form of its TRANSLATION role. In this case the L2 GU has no separate existence; it is learned directly via the L1 GU.

The WORD-TRANSLATION possibility (Figure 9) reflects a very strong reliance on the L1 during learning: in forming such an association, a learner would utilize only L1 structures. The result leaves the L2 word completely isolated from whatever knowledge there is of the L2 grammar. For instance, in the example the knowledge of the ways in which the word *water* can participate in English noun phrases of varying complexity is lacking.

Now consider the implications of the various relationships for production. Each could account for an example of transfer like that in 1) above. However, there are arguments for one or the other of the possibilities in other cases. In particular, neither the common-CONTENT arrangement nor the WORD-TRANSLATION association permits correspondences between constituents of GUs of different languages. The language-independent GU handles this quite efficiently, however.

Intra-sentential code-switching (Hatch, 1976) provides some evidence for a language-independent notion of particular syntactic roles. The following is an example from a Japanese-English bilingual (from Uyekubo, 1972; simplified somewhat for purposes of illustration).

2) *ano okanemoti wa ozyoosan o* ***spoil*** *sita*
that rich-person TOPIC daughter ACCUSATIVE spoil did
'That rich man spoiled his daughter.'

Other than the intrusion of the English verb *spoil*, this is an acceptable Japanese sentence. In a code-switching context such as this, both speaker and listener are bilinguals. For one reason or another (Hatch, 1976), the speaker selects a particular language in which to produce an utterance. In the example the target language is Japanese. When a suitable GU in the other language is accessed during production, however, there is no reason to discard it as there would be for a

monolingual listener. In the example the speaker has found the English GU U.SPOIL, and she chooses to make use of it rather than search for a corresponding Japanese GU. The result is the integration of GUs from separate languages into a single utterance.

How this actually works is quite complicated. The important point for the present example, however, is the assumption that case assignment is made on the basis of the selection of the English GU U.SPOIL. This creates a slot for a DIRECT-OBJECT with CONTENT equivalent to the SPOILED argument of the instance of SPOILing that is being referred to. Here the person spoiled is the daughter, but in the final utterance, the constituent referring to the daughter is realized as a Japanese accusative noun phrase, i.e., one in pre-verbal position folloed by the case marker *o*. The implication is that at some level the speaker has the knowledge that there is correspondence between the English direct object and the Japanese accusative. This correspondence is apparently based on semantic criteria, the knowledge that in both cases the referent tends to be a PATIENT in the event referred to by the whole clause. In the present framework, the correspondence is handled by a language-independent GU for transitive clause with language-specific specializations which share the notion of a direct-object/accusative, here referred to as ACCUSATIVE* (Figure 10). The language-specific properties of the ACCUSATIVE* include the identity of the case marker for Japanese and the post-verbal position of the argument for English.

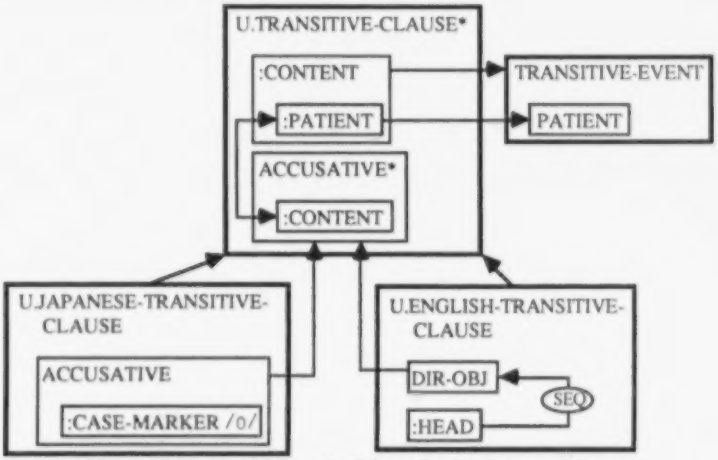

Figure 10: Notion of "accusative" for an English-Japanese bilingual

Intra-sentential code-switching such as this resembles the type of transfer that occurs during production itself, what Corder (1983) has termed "borrowing". In the present framework, this involves the accessing of a GU from the wrong language which is then used, not directly as in code-switching, but as a source of one or more target language GUs. This sort of strategy in production is possible with the language-independent GUs just described, but it is cumbersome because the path from a GU in one language to the corresponding GU in the other language passes through the language-independent GU. A more efficient alternative is the TRANSLATION role relationship, which takes advantage of the inheritance mechanism that is built into the network. Making use of the TRANSLATION role in production is straightforward. When a GU from the non-target language is accessed, the system simply inherits the information stored in that GU's TRANSLATION role.

What kind of arguments are there for the kind of direct translation strategy in production that the TRANSLATION role is suited for? The clearest case would be the representations which experienced translators make use of. The TRANSLATION role allows a translator to get from input

in one language to output in the other in a relatively direct fashion, in some cases without making any reference to the CONTENT of the input utterance.

A case could also be made for the TRANSLATION role relationship in situations where conscious translation is not called for. Consider an example of L2 to L1 transfer, sometimes referred to as "language loss" (Sharwood Smith, 1983). The speaker is a native speaker of Amharic, and the utterance is Amharic except for the code switching to English *class* and the use of the verb *wɛssade*, literally 'take', but not the standard Amharic verb for this particular meaning.

3) *lela klas wɛssed-ɛ*
other class took-3:pers:masc:sing
'He took another class.'

Figure 11 shows some of the relationships that seem to be involved in the production of this sentence. Apparently the speaker has accessed the English GU for taking a class while intending to produce an Amharic utterance (U2 in the figure) and then literally translated the English expression into Amharic. However, this process must have been accomplished very readily in order for it to win out over the alternative of searching for the appropriate Amharic GU for the notion of taking a class, U.KIFIL-TEKETATTELE. It seems that there is evidence for a relatively direct path from U.TAKE to U.WESSEDE. The TRANSLATION role is the most obvious way of accomplishing this in the present framework.

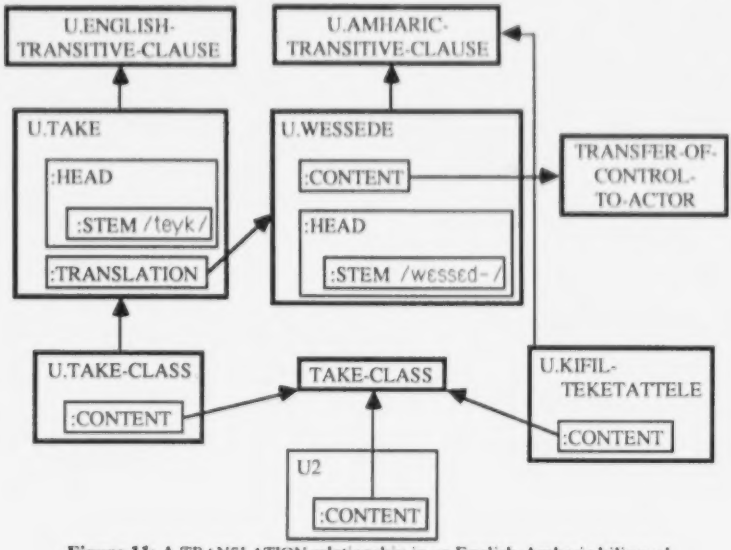

Figure 11: A TRANSLATION relationship in an English-Amharic bilingual

Finally, is there any need for the WORD-TRANSLATION possibility shown in Figure 9? One type of data that might lead us to posit such an arrangement is the early utterances of second language learners and pidgin speakers which are often described as relexifications of first language utterances. The following is an example of a Hawaiian Pidgin English sentence produced by a native speaker of Japanese (Bickerton, 1981).

4) *da pua pipl awl poteito it.*
'The poor people only ate potatoes.'

Japanese verb-final word order is apparent in this and other of Bickerton's examples. In accounting for such utterances, there are several problems with the WORD-TRANSLATION relationship. First, there is experimental evidence from work by Potter et al. (1984) that even adults in the early stages of second language study do not make use of such associations. Second, these associations leave no room for the later integration of the knowledge into the syntax of the second language. A more reasonable solution is to have generalizations for entire phrases in the second language which contain relatively little information in the early stages of acquisition. Second language GUs such as the one for English *eat* in the example, are learned as specializations of the high-level generalization U.ENGLISH-CLAUSE, which has nothing at all to say about constituent order. U.ENGLISH-CLAUSE is in turn a specialization of the language-indepedent GU U.CLAUSE*, which at this stage still specifies Japanese word order. On this view, the utterance gets its ordering from what is currently known about constituent ordering in general, namely, what is known about constituent ordering in Japanese clauses.

Conclusions

What I have presented does not answer any questions, but it does offer a descriptive framework within which questions and answers can be stated more precisely than has been done (cf. Kirsner et al., 1984). It seems clear that theories of second language acquisition, bilingualism, and translation should be prepared to deal with a variety of inter-lingual relationships. In particular, there is the possibility of correspondences between pragmatic, semantic, syntactic, and morphological elements of utterances in different languages. The use of a semantic network framework with an inheritance mechanism enables the full range of such relationships to be represented.

There is a wealth of available data which can provide constraints on what sorts of relationships are learned by people with knowledge of more than one language. The code-switching literature is particularly intriguing. There is, for example, the fact that English nouns intruding in Spanish sentences often carry the grammatical gender of the corresponding Spanish nouns (Pfaff, 1979). Our next goal is to attempt to simulate some of the transfer, code-switching, and translation data using the program. In this and future work we will be focusing on what is really the key issue: what are the consequences of various processing contexts and strategies for the learning of the various types of inter-lingual relationships described in this paper?

FOOTNOTES

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[1]This is a simplification of the semantics of utterances. A distinction is made between the REFERENT, which is the speaker's representation of the concept to be activated or created in the listener's memory, and the CONTENT, which is an abstraction of the REFERENT singling out a set of properties which the utterance is designed to pick out.

[2]This relationship is in fact more complex than a simple is-a relationship (Fahlman, 1979).

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